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BULLETIN OF THE
U.S. DEPARTMENT OF AGRICULTURE

No. 111

Contribution from the Bureau of Entomology, L. O. Howard, Chief.
July 11, 1914.

(PROFESSIONAL PAPER.)

THE SEQUOIA PITCH MOTH, A MENACE TO PINE IN WESTERN MONTANA.

By Josef Brunner,
Agent and Expert, Forest Insect Investigations.

INTRODUCTION.

In the area near and at the divide between Swan River and Clearwater River in Montana and extending, so far as known at present, about 8 miles southeast from that divide, the sequoia pitch moth (*Vespamima sequoia* Hy. Edw.)[1] is at present the most destructive insect. It menaces the lodgepole pine timber, in which it propagates, and all other trees in the vicinity of those attacked are jeopardized by the forest fires fed by the dead timber resulting from the work of its larvæ. The range of its peculiar injury to trees in that region has also been traced by the writer about 6 miles west from the wagon road which unites the Clearwater and the Swan River country from Rainy Lake toward the Mission Range. Roughly, the area in which the insect is a very serious factor in forest destruction is about 12 miles long by as many miles wide and covers about 144 sections of forest land, or more than 90,000 acres.

Control and practical elimination of this insect, as a serious menace to the very existence of the forest growth of this area, depends largely on a knowledge of its habits and life history. Insufficient familiarity with these two points would result in unnecessary waste of time in locating infested trees and in conducting control operations at a time of the year when the result would be out of proportion to the cost.

DESCRIPTION OF THE INSECT.

Vespamima sequoia (fig. 1) is a clear-winged moth in general appearance strongly resembling a hornet or "yellow jacket." This resemblance is so perfect that a truck gardener near Missoula, Mont., evi-

[1] Identification by August Busck, as the species which was first found to inhabit the sequoia.

Note.—This bulletin is a report on an insect infesting lodgepole pine in the Rocky Mountain region of Montana.

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dently familiar with the hornet, refused to believe that a specimen which had just emerged and was being observed on the tree in which it had attained maturity was not a "stinger" until the difference was pointed out to him.

The female is about two-thirds of an inch in length and the male is somewhat smaller. In the female the last three segments, and in the male the last four, are bordered with rich lemon-yellow, which makes the sexes easily distinguishable, even to the uninitiated.

The mature larva is from three-fourths inch (male) to 1½ inches (female) long and is of a dirty white or yellowish color.

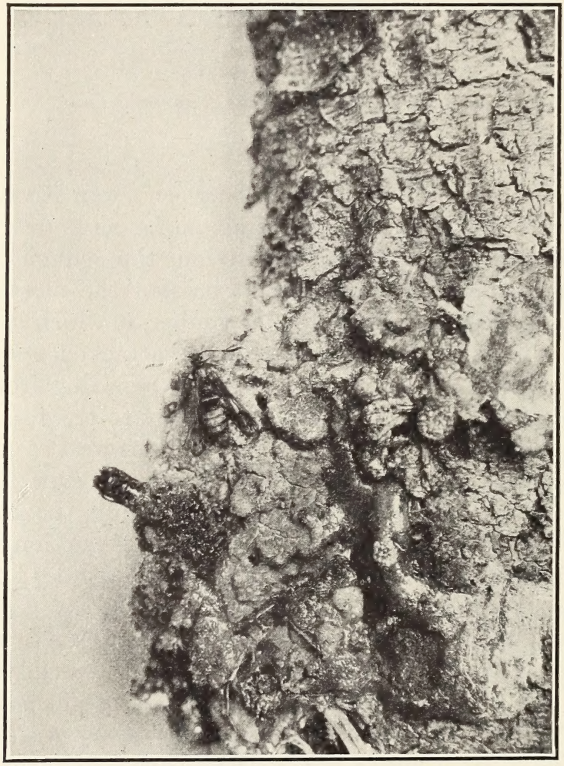

FIG. 1.—Female pitch moth (*Vespamima sequoia*) 15 minutes after emerging. (Original.)

LIFE HISTORY.

Observations on this species in different localities, together with the dates of emergence of adults reared in the laboratory, show that the general flight of the mature insects and oviposition occur between June 25 and July 15, the greater number of them probably flying about July 10. However, variation in latitude and altitude and unusual weather conditions prevailing during the spring of certain years may put the date of this general emergence a few days ahead or

behind those given here. The flight and oviposition of the insect are over by August 1.

It appears that the adult insect is rather short-lived, as all the specimens that were reared and observed in captivity died within four days of emergence. Out of 20 females thus under observation only one oviposited, the rest dying without issue. This would show that the female dies, unless she is fertilized, within three days after emergence.

As this species is very active it is reasonable to suppose that it deposits but few eggs in any one place. In fact, it was frequently observed that wherever two larvæ are too close together one of them invariably dies. Wherever an occasional pitch mass is found to contain as many as three larvæ, each one of them occupies an independent tube. This shows that the scattering of the eggs is necessary in order to enable most larvæ to survive the evidently fierce struggle for existence. Exactly how long it takes the eggs to hatch is unknown to the writer, but the injury to the newly infested trees by the young larvæ is quite perceptible by August 15. By the time frost arrests their activity, about October 1, the larvæ, especially the females, have attained considerable size. The following summer is devoted by the larva to lengthening the tunnel and growing, and toward the second winter it drives a rather roomy tunnel into the pitch exudation which, during the following June, it lines with silky thread preparatory to pupation.

During the two months preceding pupation all the larvæ of the same sex are of practically the same size, so that the two generations are almost inseparable. However, one familiar with this and allied species can separate them by the difference in color and density of skin, which is rather white in the younger generation and yellowish, leathery, in the older one.

The length of the pupal stage is 30 days, i. e., the insect remains in the chrysalis for 30 days from the day it transforms into that stage until it emerges as adult. The chrysalis is free in the tunnel, moving back and forth in it at will by means of spines on the body, and is usually found on warm days quite near the surface and far back when it is cold. When ready to emerge the pupa forces about half its length out through the thin shell of pitch at the mouth of the tunnel and the adult insect (fig. 1) emerges by bursting the shell of the chrysalis. This occurs two years after the egg was laid. In other words, the larvæ hatching from the eggs deposited in June and July of one year develop into adults during the same months two years later, thus making the generation biennial.

There seems to be indication of an alternation of seasons of abundance and scarcity of the insect. During late autumn, 1913, the young larvæ were quite scarce in the vicinity of Rainy Lake, especially east of the wagon road from Clearwater to Swan River, while

1-year-old larvæ were abundant. If this observation holds good, the insect being biennial, we should be able to forecast the years when it will be abundant and when scarce. Hence there should be great flights during 1914, 1916, 1918, etc., unless the insect is controlled, and small flights during 1915, 1917, 1919, etc.

RELATION TO THE MOUNTAIN PINE BEETLE.

The only insect which is of any consequence in its relation to the pitch moth in the Clearwater country is *Dendroctonus monticolae* Hopk. This beetle frequently attacks trees infested by the larvæ of the moth. This attack is always fatal to the latter, because Dendroctonus kills the tree almost immediately, and without the flow of sap the larvæ of the moth can not survive. On October 1 every larva of the moth which was found in trees attacked by the beetle after August 1 was dead. Some of the trees had the appearance of having been infested by the beetle only two or three weeks; nevertheless, the moth larvæ were dead, although they were in perfectly fresh condition otherwise.

Vespamima sequoia is apparently little subject to attack by either parasitic or predaceous enemies. In fact, it is less troubled by insect enemies or diseases than any other species known to the writer; and as birds also never seem to pursue it, there is no present evidence that natural agencies might check it in the course of time.

HABITAT.

The insect prefers sunny openings within the forest and slopes where the soil is rather sandy and quick to dry. Ridges along watercourses are also favorite places for it. It avoids the damp and densely shaded bottom lands along streams. It prefers pine, open stands of lodgepole pine, as, for example, within and alongside the big old burn which extends from the wagon road toward and along the Flathead Range, where there are few trees 3 or more inches in diameter that have escaped attack and are not infested now.

HOST TREES, AND CHARACTER OF INJURY.

Lodgepole pine is numerically the principal species of tree in the region and, with the rare exception of the yellow pine, is the species subject to attack by the pitch moth, although the moth attacks almost all kinds of conifers in other localities within its range.

The trees infested by this insect (see fig. 2) are readily located by the never-absent pitch exudation over the tunnel of the larva. This may be readily seen at quite a distance, if the stand of trees is not too young. Even on very small trees of but 1 or 2 inches in diameter the pitch tube is of the size of a walnut the first season of the infestation and more than twice that the second year.

The pitch exudation on the tree shown in figure 3 weighed over 10 pounds, and such trees are so numerous that many tons of pitch

could be collected within the comparatively small area infested by this insect.

The trees are all of them attacked at the extreme base, and the exuding pitch flows out from the tree not infrequently a distance of 10 or 12 inches upon the humus which covers the ground.

THE WORK OF THE LARVA.

The larva begins its mine in a crevice in the bark, where the egg was deposited, proceeding through the outer layers until it reaches the cambium. Close to the wood it begins to construct a transverse

FIG. 2.—Lodgepole pine trees infested by the sequoia pitch moth. Trees of all sizes are infested in the Clearwater country of Montana.

mine running in both directions from where it entered. It widens this tunnel at the center, thereby causing the appearance of a central chamber. In small trees the mine is always practically straight across the grain of the wood.

It is a puzzle to the writer how the larva determines how far it can go in the two directions without entirely girdling the tree, thus killing it and thereby depriving itself of sustenance. It is a noteworthy fact that of the great many trees less than 3 inches in diameter examined, all were found girdled to within 1 or 2 inches, and none entirely girdled.

It is evident that the entire girdling of about 0.5 per cent of the older infested trees is accomplished by more than one larva which happen to infest these trees at one and the same time. Each larva evidently tries to get as far away from its neighbor as it can, and thus the tree is girdled. But, as indicated, plural infestation is rare. To test this point experimentally the writer has several times planted in captivity two larvæ on one piece of wood, and invariably one of them left the sustaining slab. On a few occasions when, because

FIG. 3.—A lodgepole pine tree infested by the sequoia pitch moth. The new, flowerlike exudation indicates present infestation. (Original.)

none vacated, the writer supposed he had made a success of "double planting," he found later that one of the larvæ was dead.

Tunnels in trees infested only the second year, as well as those in trees that have been infested by several successive generations of the insect, look as if they had been engraved by the larvæ eating the wood, but such is not the case. The appearance is caused by the larvæ preventing the wood from forming a new layer across the tunnel. Thus the tunnel, in the course of many seasons, gradually becomes deeply embedded in the wood tissues.

In rare cases the tunnel is slightly slanting, running on one side of the center, a few inches below the surface of the ground, while the end

of the other side is several inches above ground. Under no circumstances is the tunnel parallel to the grain of the wood.

As stated, the activity of the larvæ within the cambium of the tree causes a heavy flow of pitch toward the exterior, and fresh, flowerlike nodules upon older exudations (fig. 3) are a definite proof that the tree is still infested.

EFFECT OF THE INFESTATION ON TREE GROWTH AND THE FOREST.

It is obvious that with one-half and, in the majority of cases, two-thirds of the circumference of the tree trunk cut off from the root

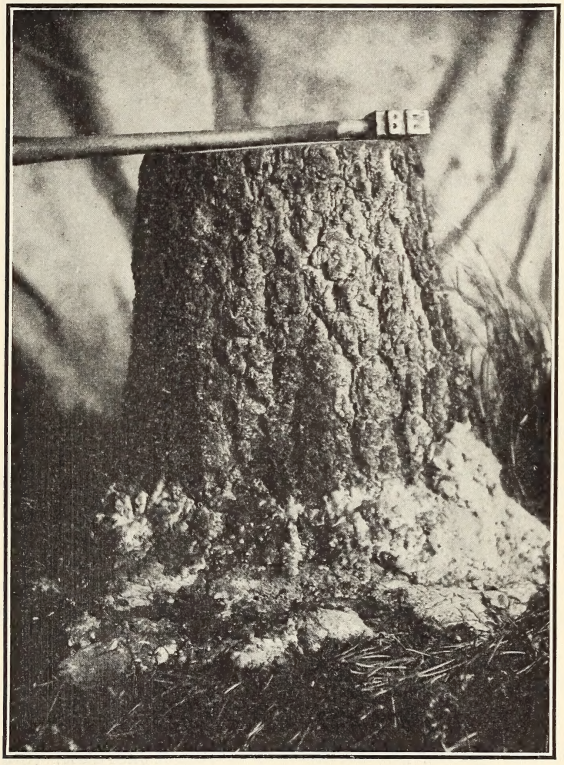

FIG. 4.—Stump of a pine tree 64 years old which grew to be 9⅞ inches in diameter breast high at 41 years of age and added only seven-eighths inch to this diameter during the last 23 years of its life, owing to attack by the Sequoia pitch moth. (Original.)

system by the dividing tunnel, the growth of the afflicted tree has to suffer. Count of annual rings and measurements on a tree which was considered to be a fair example of the general injury in the area brought out the fact that during the first 41 years of its life and normal health it had added annually about one-fourth inch to its diameter, while it added only about one thirty-second of an inch, or the thickness of an ordinary visiting card, annually during the 23 years it had been infested by the pitch moth. (See fig. 4.)

SECONDARY INJURY BY FIRE.

About one-half of 1 per cent of the trees infested by *Vespamima sequoia* is killed. In case of a slight surface fire in places where, outside of humus, no litter covers the ground, all the infested trees which are not killed outright come through it with the bark on the sides where the pitch exudation is located literally cooked, and for the balance of their existence they display the "fire wounds" (fig. 5), of which the pitch moth was the primary cause. They remain green but add little to their size annually. Subsequent fires fell them

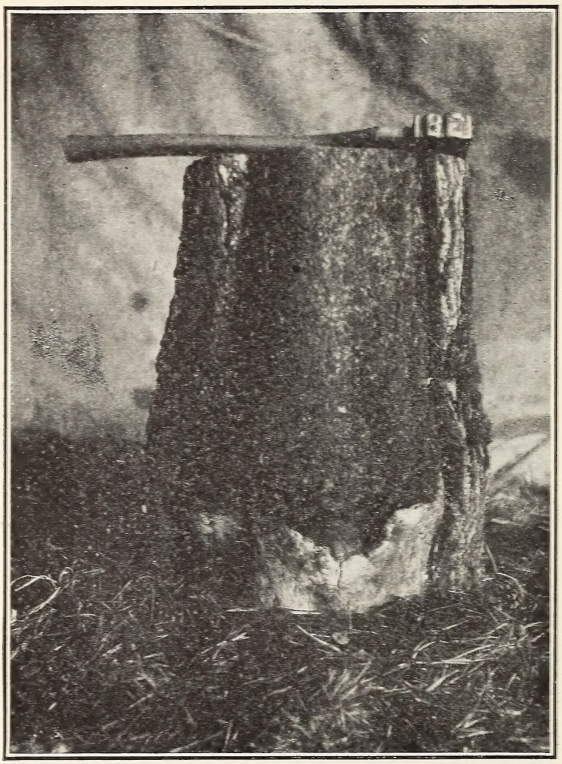

FIG. 5.—Fire wounds on pine tree injured by the Sequoia pitch moth. (Original.)

readily, and their burning injures and kills perfectly healthy trees, which would otherwise have remained unscathed.

There is abundant proof in the area under discussion that unattacked trees, on ground not littered with fallen timber, pass through surface fires with but slight injury. Thousands of such trees are mingled with as many which display "fire wounds" and the tunnel of Vespamima burned indelibly into the base of the latter, thus explaining why it is that some trees are half burned while others, under the same conditions and at the same place, have escaped with scarcely a scar.

Many trees with fire wounds are reinfested on the sound side and killed, thus adding to the material which makes a surface fire in the area really serious. The heat generated by them in burning, either standing or prostrate, injures and kills healthy trees in the immediate vicinity.

During decades fallen timber, primarily caused by insects, accumulates and provides such an amount of inflammable material among the uninjured green trees that finally a fire sweeps such areas clean of all tree growth and enters and destroys adjoining areas which contain healthy trees only.

In the infested zone in the vicinity of Rainy Lake the forest looks much like a checkerboard. There is an area of 50 acres here with a stand of 10-year-old trees on them; adjoining this is a square-cut piece of 200 acres with 40-year-old trees as a cover; next to this are 80 acres on which reforestation started only a few years ago, and so on. This thing has been going on for at least 100 years, so far as can be traced, and probably existed before time was counted. Everyone of these variously aged tree patches is the result of a separate fire. The explanation of the occurrence of so many of them within an area comparatively so small is found in the peculiar meteorological conditions prevailing here.

TOPOGRAPHY OF THE AREA.

Running from the southeast toward the northwest are the rocky walls of the Flathead Range; west and parallel to it lies the Mission Range; and on the divide between Swan River and Clearwater River, extending from the Mission Range toward the wagon road which passes over the lowest elevation, and running from west to east is a high ridge. This ridge forms an effective barrier to storm clouds driven up Swan River between the walls of the Flathead and Mission Ranges. Their only outlet is between that ridge and the Flathead Range over the Rainy Lake territory.

The clouds driven up Swan River, inconsequent though they might be under different conditions, strike the ridge dividing the two water courses and are promptly thrown back upon their own mass by the resistance of the ridge. On the west are the walls of the Mission Range, so there is no escape for them in that direction; thus they drift eastward and toward the outlet over Rainy Lake. Part of them escape there. But the greater part are thrown upon the walls of the Flathead Range, from which they tumble back upon the oncoming mass in a turmoil before this also by and by finds its way to the only avenue of escape. The great numbers of lightning-struck trees in this area abundantly testify to the great rôle played here by lightning.

Remembering that in the comparatively small zone about Rainy Lake infested by the pitch moth there are tens of thousands of trees with heavy pitch exudation at their base which, once ignited, will burn for several days, rain or shine, and that during the violent thunder storms there many trees are struck by lightning and the pitch set on fire, we will have the combination which explains the frequency of fires in that area.

Let us illustrate. Lightning strikes a tree infested by Vespamima and sets it afire. During the storm the ground is soaked sufficiently to prevent the fire from spreading. The pitch, however, owing to its thickness and inflammability, continues to burn. On the following day a clear sky allows the sun to dry the ground cover around the burning pitch sufficiently so that a surface fire is started which will be ended by the next shower. If the stand consists of medium or small sized trees and the area has passed through fires before, everything is killed, and the place, when it has been reforested, will stand out clear in the checkerboard of forest and elemental battles even after half a century or more, as is the actual case in this territory.

As storms are evidently quite frequent there, the patches burned are usually small, ranging from 50 to 200 acres. However, there are also some burns which an accumulation of débris had undoubtedly so augmented that whole sections were swept. All the traceable evidence in the biggest burn in the area points to insect work as the primary cause, just as in the smaller burns where the evidence is more definite and is easier of location.

With a knowledge of these facts, one can not but conclude that the peculiar results of the work of *Vespamima sequoia* are the chief and primary contributing cause of the frequency, we might almost say continuity, of fire damage to forest growth in this area. To eliminate or ameliorate this condition, it is manifestly necessary to eliminate the insect or at least reduce it to such an extent that it loses its menacing aspect.

REMEDY.

Since nature and its agencies are powerless in the control of this insect, the scourge has to be combatted by man through direct action if it is not to continue its injurious activity in the future as it has in the past. There is only one way to reduce the insect, and that is to destroy it while it is in the larval stage.

As is apparent from the portion of this bulletin relating to the life history of the moth, larvæ can be found in the infested trees at any time of the year.

However, in order to destroy the greatest number of them with the same amount of effort, operations should be conducted during the months of September to June, inclusive, when there is no snow on the

ground to cover the pitch exudations. During most seasons the snow eliminates November, December, and January as control months.

By September 1 all of the eggs which have not been lost have hatched, and the young larvæ have attained a size sufficient so that they can be seen and destroyed, and up to June 25 hardly any of the second-year larvæ have reached the adult stage.

The statements under "Habitat" suggest where to look for infested trees. To locate the larvæ, separate the pitch exudation from the trees, thereby exposing the larvæ. Killing the larvæ outright, or taking them up for later counting and destruction, or, in other words, hand picking, is really the only thing that can be done to reduce the numbers of the insect.

RECOMMENDATIONS.

If the control work is done without utilization of the pitch, it will be at direct cost; and the taking up of the larvæ, though slower than destruction on finding, is preferable, as it enables a proper checking up of the extent of damage and of the amount of control work accomplished. But if the pitch is of sufficient commercial value to pay the cost of its collecting and shipment, it would be possible to control the insect by utilizing its products.[1] If the pitch is marketed, it is not necessary to keep a close check on the work beyond keeping tab on the weight of the pitch shipped and the returns from the sales.

NOTE.—The statements in this paper, with the exception of those under "Description of insect," "Life history," "Relation to the mountain pine beetle," and, to a certain extent, "Remedy," refer to *Vespamima sequoia* in the Clearwater country of Montana alone and are not applicable in other regions where the destructiveness of the insect is known to assume a different character.

[1] Just before going to press analyses of these resins were received from the U. S. Bureau of Chemistry, with the following comment.—A. D. HOPKINS, *in Charge of Forest Insect Investigations.*

"The volatile oils obtained from these two resins are slightly heavier than ordinary oil of turpentine. They show smaller percentages, distilling below 170° C. However, as turpentines as heavy as these will find a market as paint and varnish thinners, it is anticipated that no difficulty would be encountered in disposing of the turpentine produced from this material. Especially is this opinion held since * * * it is more than likely that owing to the size of the sample and the manner of packing, as well as the exposure of the crude gum, the percentage of volatile oil is lower than it would be in material which was collected in the ordinary commercial way.

"The rosins do not appear to differ essentially from the rosin made from longleaf pine, and we have no hesitation in expressing an opinion that it would be entirely suitable for soap-making purposes and would command the ordinary market price according to the grade. Attention may be called to the fact that lighter colored rosins, therefore higher grade rosins, would undoubtedly be made in practice, provided bark, dirt, etc., are kept out of the resin.

"Nothing was observed in this examination which would warrant the opinion that the nature of the product was due to the particular manner of its production. It is believed that essentially the same product would be obtained by the ordinary commercial chipping of the tree except so far as prolonged exposure on the trunk of the trees, as probably took place with these samples, favors volatilization of the light oils and this affects the relative proportions of volatile oils and of rosin and the specific gravity of the oils."—F. P. VEITCH, *Chief of Leather and Paper Laboratory, Bureau of Chemistry.*

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1914

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